Department of Agriculture
and Fisheries for Scotland

The Aberdeen Single-Anchor Mooring

R Payne

Scottish Fisheries Research
Report number 1

OCT 24 1975
FISH & WILDLIFE SERVICE

The Aberdeen Single Anchor Mooring

R. Payne

Marine Laboratory, Aberdeen

Introduction

The type of single-anchor mooring described in this report (Fig. 1) has been successfully installed and recovered in depths of up to 1000 m, well within the design depth capability. It has proved simple to handle, both from a modern research ship with bow-thrusters, hydraulic cranes and special winches, and from a side trawler, using the trawl winch and the yo-yo derrick. Indeed the basic technique varies only slightly from vessel to vessel.

The instruments used on the rigs are the Aanderaa current-meter and the Aanderaa thermistor chain, recovery being effected by an AMF (American Machine and Foundry) acoustic release.

The design of this single-anchor mooring began in 1970, much of the early effort being devoted to finding the most suitable form of sub-surface buoyancy.

The first sub-surface float was a syntactic foam module, which had a very poor weight/buoyancy ratio, although it would have gone much deeper than required. Next came lighter syntactic foam-coated modules, which also proved inadequate, and 'Nokalon Blue Super' trawl floats, which gave rise to handling problems and presented a very high drag. All these were used on anchor-first moorings, and presented difficulties in handling the equipment under strain mainly because of the large number of bollards and blocks required to achieve the correct lead. At this time 7 mm diameter stainless steel wire with a breaking strain of 2 tonne was used.

In 1972 the procedure was changed to the anchor-last method, using a 1.22 m diameter glass-reinforced plastic (GRP) sphere as a sub-surface float and using galvanised wire with an increased diameter of 8 mm and a breaking strain of 3.56 tonne. Unfortunately the GRP spheres imploded at 80 m depth and their use was discontinued.

Despite the failure of these floats some valuable experience in handling single-anchor, anchor-last rigs had been acquired. For example, initially additional buoyancy was attached to the wire during deployment to keep the mooring in a straight line on the surface. This buoyancy consisted of polystyrene blocks attached to the wire with soluble string but experience had shown that this could be dispensed with, speeding up the operation and allowing the wire to hang in a shallow catenary between the buoy and the ship.

Various Karabiners and snap-links in the connections were also tried, but experience proved the pinned shackle to be superior from the point of view of corrosion and the overall safety of the mooring. The desirability of connecting up shackle-ring-shackle became evident over this period.

The proven 1.22 m diameter steel sphere developed at the Institute of Oceanographic Sciences, Wormley, Surrey, was used in 1973, and with this sub-surface buoyancy module it was possible to carry out full dress rehearsals of the techniques before fully instrumented moorings were used during the international hydrographic expedition between Greenland and Shetland called "Overflow '73" (Table 1).

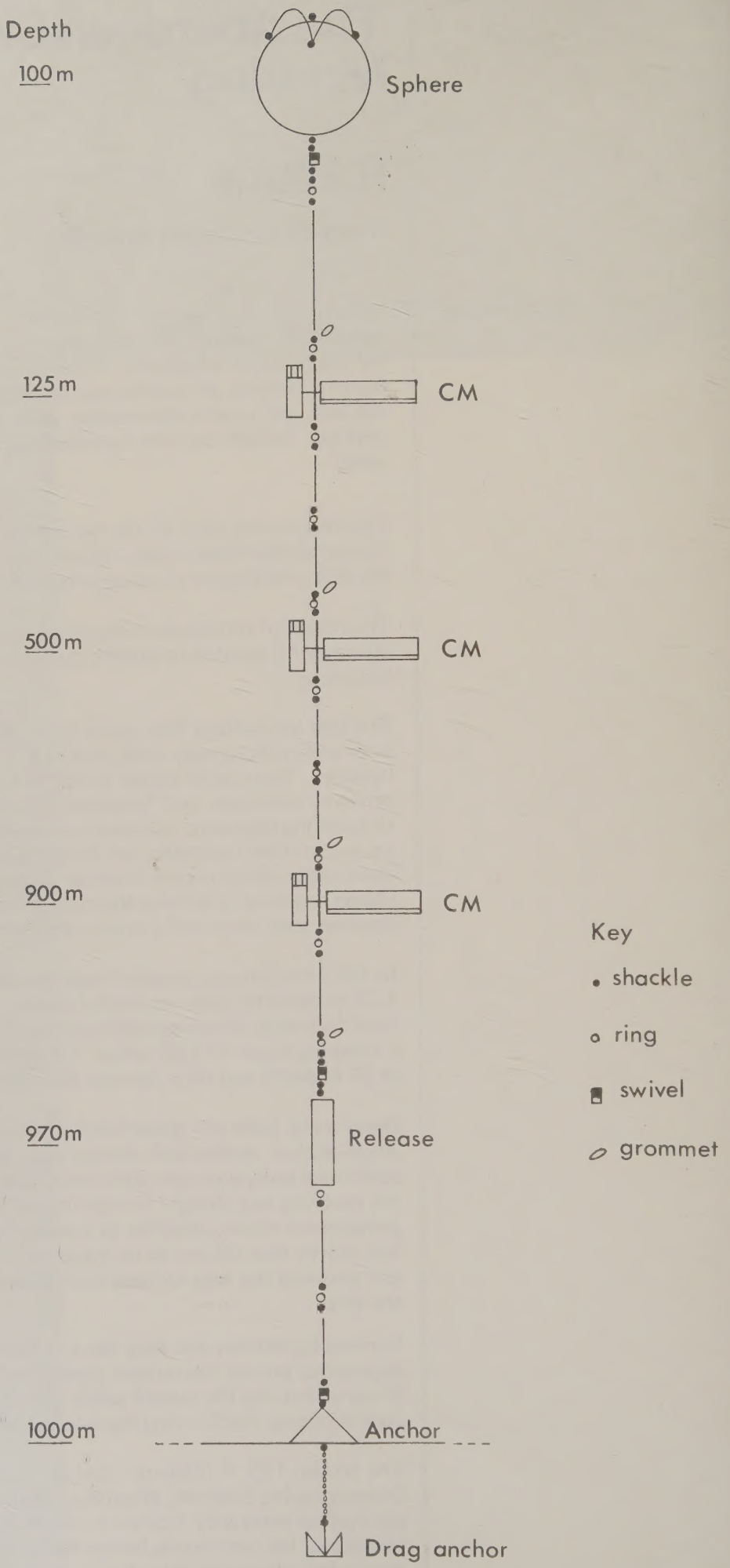

Figure 1. The Aberdeen single-anchor mooring.

1 60°29.5'N, 04°26.0'W in 985 m of water

Instrumentation: Aanderaa Current Meter 110 m
885 m

Aanderaa Thermistor Chain 285-335 m

Date: 18.8.73 - 13.9.73 AMF Acoustic Release

2 60°44.5'N, 05°03.2'W in 912 m of water

Instrumentation: Aanderaa Current Meter 137 m
812 m

Date: 19.8.73 - 11.9.73 AMF Acoustic Release

3 60°30.171'N, 04°25.393'W in 1010 m of water

Instrumentation: Aanderaa Current Meter 135 m
510 m
910 m

Date: 25.5.74 - 11.8.74 AMF Acoustic Release

4 60°44,678'N, 05°03.940'W in 915 m of water

Instrumentation: Aanderaa Current Meter 140 m
815 m

Date: 26.5.74 - 11.8.74 AMF Acoustic Release

TABLE I Single-anchor moorings used by the Marine Laboratory, Aberdeen

Early in 1972 it became possible to check the stability of the rigs by means of the computer program SHAPE (Barber, 1971). This program produces a detailed analysis of the displacement and tensions of a single-anchor rig throughout the wire length.

The analysis demonstrated the difficulties in the use of a surface marker in the current conditions expected in the Farce-Shetland channel. This marker resulted in a wire angle at the bottom of 37°, whereas without a surface marker the wire angle was 20°. Since the Aanderaa current meter can tolerate wire angles of only up to 27°, and because of the practical difficulties of shooting a surface marker with 600 m of buoyant rope, it was decided to remove the marker from the rig.

The Equipment

The sub-surface buoy

The sub-surface buoy is a 1.22 m diameter steel sphere designed by D. Gaunt at the Institute of Oceanographic Sciences. The material used is carbon steel plate to BS 1501/101 tensile strength 47 kg per sq mm. The sphere is made up from two spun hemispheres, welded equatorially with a nominal thickness of 7.925 mm. The weight is 317 kg in air, giving a net buoyancy of 680 kg in water. The maximum safe working depth is 600 m, incorporating a safety factor of x 2.

Four 13 mm diameter wire loops are fitted to the four lugs on top of the buoy to enable grapnels to grip and the crane hook to lift the buoy on recovery.

The wire

Galvanised wire is used between the acoustic release and the sub-surface buoy. Its specification is: 8 mm diameter, 18 x 7 fibre main core, right hand ordinary lay, performed, tensile strength 180 kgf per mm^2 galvanised, 'Kilindo', multi-strand, non-rotating, with a breaking load of 3.66 tonne.

The 15 m lengths between the anchor and the acoustic release are of similar specification but are of 13 mm diameter, with a breaking load of 9.65 tonne. This wire serves two purposes in that the length ensures that the release will

not hit the sea-bed when the anchor strikes the sea-bed and the diameter of the wire ensures that there will be no damage from handling when attaching the anchor and during deployment.

All wires are terminated with a hard eye using a galvanised steel thimble and double copper Talurit ferrules. Thirty centimetres from the end of each wire four aluminium Talurit ferrules are pressed onto the wire acting as sacrificial anodes to protect each coupling

Shackles, rings and swivels

For ease of handling, most connections are made shackle-ring-shackle. The shackles used are galvanised steel 13 mm pin diameter drilled through the shoulder and pinned with a 2.4 mm diameter stainless steel split pin. To accommodate the swivels a larger shackle is used of galvanised steel, 19 mm pin diameter drilled through the shoulder and pinned with a 3.2 mm diameter stainless steel split pin.

The 13 mm steel galvanised rings of 76 mm outside diameter serve mainly to give flexibility to the couplings, particularly necessary when shackles have to be handled in cramped situations. Between the two 15 m lengths of heavy wire at the bottom of the mooring is a 25.4 mm steel galvanised ring of 127 mm outside diameter.

The swivels are the SW35S made by Frekhaug Metalstopperi, Frekhaug, Norway, with a safe working load of 3 tonne.

The main anchor

The main anchor is made up of scrap used stud-link cable in two clumps of about 385 kg each. These are the standard clumps used with our "U" moorings (Payne, 1975). Each clump is held together with a 9.5 mm link chain, the two ends of which are shackled together giving a single clump anchor weight of about 770 kg. The exact weight of each anchor used is determined by means of a 'Crane weigher'.

The drag anchor

Attached to the main anchor is a 10 m length of 13 mm galvanised steel chain terminating in a 34 kg 'Danforth' type anchor, known as a Meon Mk7. This anchor will withstand a 4,500 kg pull in good holding ground. It is added to the rig simply as a safety measure to avoid the rig 'walking' in very high current speeds or when the mooring is deployed on the continental slope.

The acoustic release

The release used is an AMF Model 242.

The roller leads

On the Fisheries Research Ship "Scotia" a wide roller lead is incorporated into the rail aft of the forward gallows under the crane. On FRS "Explorer" a seine-net roller is slotted into the rail under the yo-yo derrick.

Procedure

Preparations for shooting

A messenger is run onto the barrel of the winch, and, commencing at the 127 mm outside diameter ring, the wire is run onto the winch. All shackles and swivels are on the wire, which will be split when shooting to take current meters and the release. The wire is run off drums directly onto the winch using the 'Rolladrum', the maximum length of any individual wire being 200 m for ease of handling. Once the wire is on the barrel the loose end is run out through the gallows, a 90 kg weight attached, and the wire is lowered as far as the 127 mm outside diameter ring. It is then hauled in slowly, taking out any turns, pre-tensing the wire and enabling the wire to be spread evenly on the barrel. Shackles and swivels are, wherever possible, kept to one side of the barrel. While the pre-tensing progresses a large snatch-block with a 200 mm throat is positioned directly in front of the winch barrel and at right angles to the roller lead over the side (Fig. 2). When the wire is back on the winch, the end is run through this snatch block and over the roller lead and connected to the base of the sub-surface buoy. The chain anchors are swung out, shackled together, and hung from the gallows by a rope stopper. A 15 m length of heavy wire runs from the anchor round the gallows and back on board. The 10 m chain and Meon Mk 7 anchor are attached to the main chain anchor, and a short rope stopper is placed between the snatch-block and the rail with a screw-gate Karabiner in the free end.

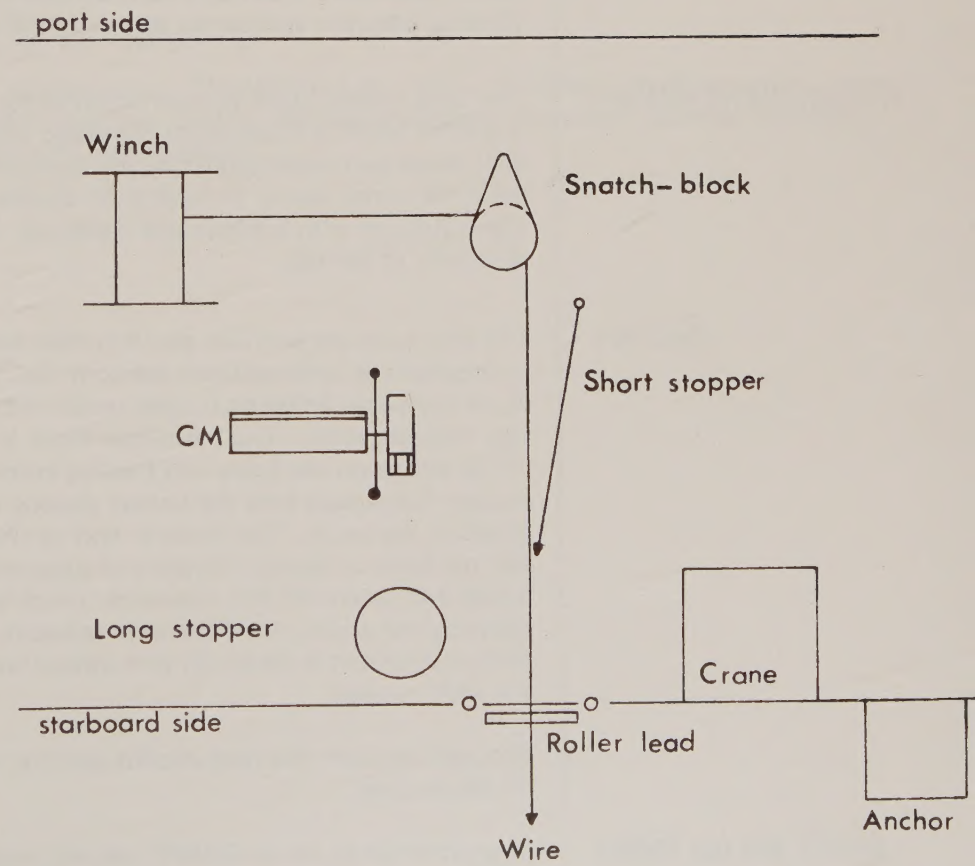

Figure 2. Diagram of deck lay-out for shooting a single-anchor mooring.

A long rope stopper 40 m long is made ready near the rail. Finally the current meters and the release are brought out on deck. Meanwhile, a survey is made of the mooring area to check the depth and local bottom topography, which is obtained from a timer-counter connected to the echo-sounder, calculated and corrected from estimates of sound velocity which give an accuracy of 0.1%. The ship is positioned upwind-upcurrent of the intended shooting position.

Shooting

Some slack is run off the winch, and the crane, using a yo-yo slip hook, lifts the sub-surface buoy and places it in the water. The hook is disengaged and the wire paid out. Depending on the weather conditions the ship will drift away from the buoy or if necessary be driven away from it using the engines. On the approach of a double group of shackle-ring-shackles, where a current meter will be placed in the wire, the short stopper is prepared and as soon as the shackles have passed the snatch block the Karabiner is clipped in to the leading shackle. The short stopper now takes the strain and the wire can easily be split and the current meter shackled in. A 228 mm outside diameter polypropylene grommet is put into the leading ring. The winch takes back the strain, and the short stopper is disconnected. The yo-yo hook is put into the grommet and the meter and wire raised just high enough to clear the rail. When the current meter is well clear of the rail the yo-yo hook is disengaged. The rest of the instruments and the AMF release are attached and put over the rail in the same way. The sub-surface buoy should be away on the beam at a distance equivalent to approximately half the length of the mooring, with the wire a shallow catenary between it and the ship. Finally the 127 mm outside diameter ring between the rig and the messenger is passed through the snatch block. A long rope stopper is put through the ring and made fast. The 15 m 'tail' of wire from the anchors is shackled into the ring. The messenger is unshackled and the long rope stopper is slacked away, the strain then coming entirely on the rope stopper holding the anchors. The rig is now ready to be dropped. After a last check on position and particularly depth, the anchor stopper is allowed to run free. The anchor has a terminal velocity of about 150 m per minute but this is reduced considerably in the last 100 m or so when the sub-surface buoy has submerged. The sub-surface buoy is pulled a considerable distance through the water towards the ship before it submerges to a depth of about 100 m.

Preparations for recovery

The large snatch block is maintained in the same position as for deployment. A similar block is shackled to the crane wire and positioned to give a lead well above and slightly outside the starboard rail. The messenger is passed from the winch barrel through both blocks and a hook attached. A short chain stopper with a screw-gate Karabiner is positioned at the rail. Grapnels are ready at the rail.

Recovery

The ship takes up position about ½ mile from the rig. The AMF transducer-hydrophone is streamed and the command given for release. The ship steams up to the buoy, bringing it close under the starboard side. Grapnels facilitate this operation. The messenger hook is snapped into one of the four lifting strops on the buoy and hauling commences. The Karabiner on the stopper is snapped into the lowest shackle under the buoy and the strain eased on the buoy. The shackle next to that which is stopped off is removed, and the buoy is swung inboard and lowered to the deck. The hook is released and taken off, the messenger shackled to the rig, the strain taken up again by the winch, the Karabiner released, and hauling commences again. Each instrument is taken off in a similar way, ending with the recovery of the AMF release.

The main anchor, the drag anchor and the two 15 m lengths of wire are left on the sea-bed.

SHAPE and the 1000m "overflow '73" mooring

In an attempt to check SHAPE use was made of data obtained from the 1000m mooring in "Overflow ' 73" (Table I, No 1) which had a recording thermistor chain incorporated at a depth of 285-335 m.

Using Barber's calibrations and applying the actual maximum current speeds experienced by the rig (+ 100 cm s^{-1} from 0-550 m, -25 cm s^{-1} from 550-1000 m), the results of SHAPE gave an angle at 900 m of 33°. This appeared excessive since the Aanderaa at this level worked well and it would not have worked at 33°, having a maximum tolerance of 27°. It also gave a downward displacement for the buoy of 80 m.

The various weights were carefully recalculated and also the drag coefficients of the wire for the actual currents experienced. With the new calibrations SHAPE gave an angle at 900 m of 27°, which still seemed excessive, being the critical angle for the current meter. The downward displacement for the buoy was computed at 58 m

The temperature profiles from the hydrographic stations worked at the buoy position were compared with the thermistor chain data, but these did not identify any downward displacement of the rig due to wire angle..

Furthermore, the thermistor chain record was subjected to periodogram analysis, which showed peaks of 0.18°C at 12.5 hours and 0.04°C at 25 hours. There was no evidence of a peak at around six hours, which would have occurred if the rig angle, and the consequent downward displacement of the buoy, had been very large and varying tidally. This again suggests that the SHAPE results were excessive for the given speeds.

It is suggested that SHAPE is adequate for speeds of up to 50 cm s^{-1} but will give exaggerated results for greater speeds.

References

Barber, T.R. 1971

Steady displacements of moorings produced by ocean currents. NIO Internal Report No. A 54.

Payne, R. 1975

(In preparation). The Marine Laboratory, Aberdeen, shallow water current meter mooring. DAFS, Marine Laboratory, Aberdeen, Scottish Fisheries Research Report No. 2.